# Goodhue County Land Use Management

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US Geological Survey

September 8, 2021

RE: Goodhue County Lidar Project G20AC00107 - FY20 3DEP BAA 2020

David,
This is follow up information about our process for collecting data with RTK.

We spoke with Leica and were told that a RTK GNSS Receiver from any top manufacture can yield 0.033-ft Horizontal and 0.055-ft vertical, which is 1.003 cm Horizontal and 1.676 cm Vertical.

Leica said adding the GLONASS and Galileo Constellation, L5 and double averaging from RTN Networks can further improve the measurement performance.

Goodhue County is using GPS, GLONASS and Galileo satellite constellations in our real time solution. Our receivers are also automatically using L5. MNDOT CORS and the Leica Smartnet Reference Network uses the full GNSS constellation including L5.

We typically see more than 12 satellites available at any given time.

We routinely achieve better than 0.033 ft Horizontal and 0.055 ft Vertical as we collect 20-40 seconds of observations from the MNDOT VRS network and reinitialize with the Leica Smartnet Network and repeat that process to attain an average from two independent reference networks. Our points have at least 40 to 80 one second epochs of averaged occupation times from two independent GNSS Reference Networks.

Our typical live RTN quality in an open area displays 0.027 ft 2d and 0.035 ft 3d on the data collector screen, or 0.82cm 2d (x,y) and 1.06 cm 3d (x,y,z).

Quality Indicators:
We always ensure our rover unit is set to display all available coordinate quality indicators for our position fix and we pay close attention to them. In most situations these indicators reflect the actual live performance of our system.

We are aware that when positioning in severe environments our CQ values may be overoptimistic.

Coordinate solutions where the reported quality is worse than 100 mm generally result from problems with satellite lock or ambiguity resolution. Poor quality observations are always discarded or automatically not allowed to be included in the point averaging. Our data collectors warn us audibly and visually when there are ambiguity problems.

Improving solution robustness:
For a topographic survey, the use of a 5 second single window average will reduce the effect of individual coordinate solution variations.

For precise work, especially where the height component is important e.g., control station establishment or PLS Corner collection, the process of double averaging from two independent reference systems is always undertaken.

With low Ionosphere errors, low Tropospheric errors, no signal obstructions or multipath, a good geometric configuration of satellites and double network averaging of the points, you can improve the solution robustness. The software displays the quality of the point both in the data collector and in the Office Software as shown below: The results are Real-Time.

Units below are feet:

Project Ayers_2020_NVA_VVA

| Point Id | Point Class | Date/Time | Easting | Northing | Ellip. Hgt. | Ortho. Hgt. |
|---|---|---|---|---|---|---|
| 1025 | Averaged | 05/20/2020 13:34:25 | 565555.6010 | 215342.1200 | 777.1370 | 873.6425 |

| Geoid Sep. | Code | Sd. Height | Hgt. Qlty | Posn. Qlty | Posn. + Hgt. Qlty |
|---|---|---|---|---|---|
| -96.5054 | UA | 0.0032 | 0.0032 | 0.0156 | 0.0159 |

We continuously monitor the quality indicators live. We view the quality of the final point while in the field on the data collector.

In more severe conditions with potential multipath, we increase our occupation time and averages. These conditions would not be used for any type of control point establishment.

Our GNSS system resolves ambiguities quickly and stays fixed or locked during the collection period.

We never use less than a 10 degree satellite elevation mask and project parameters are checked in the data collector. Our correction data is updated every 0.2 seconds with no discernable latency. Our cellular data coverage is very robust.

We enable the Galileo Constellation and L5 in the Real Time solution to improve the measurement performance.

We avoid multipath conditions. Only the Forested points had any potential Multipath issues while the other points were in the clear.

We avoid electrical interference form high voltage electrical grid and RF from broadcast antennas.

Solar activity remained at very low levels throughout of collection period. We monitor Space Weather to ensure that we are not working during high periods of solar activity.

HDOP ranged from 0.6-1.0 which is excellent.
PDOP ranged from 1.0-1.3 which is excellent geometry.
VDOP is typically 0.8-1.3

We have two MNDOT GNSS Reference Stations located in Goodhue County. One is located in Red Wing at the Goodhue County Government Center and the other is at a MNDOT facility in Zumbrota MN.

We have two Leica Smartnet GNSS Reference Stations in Goodhue County. One is located in Red Wing at the Goodhue County Government Center and the other is at a Goodhue County Facility in Kenyon MN.

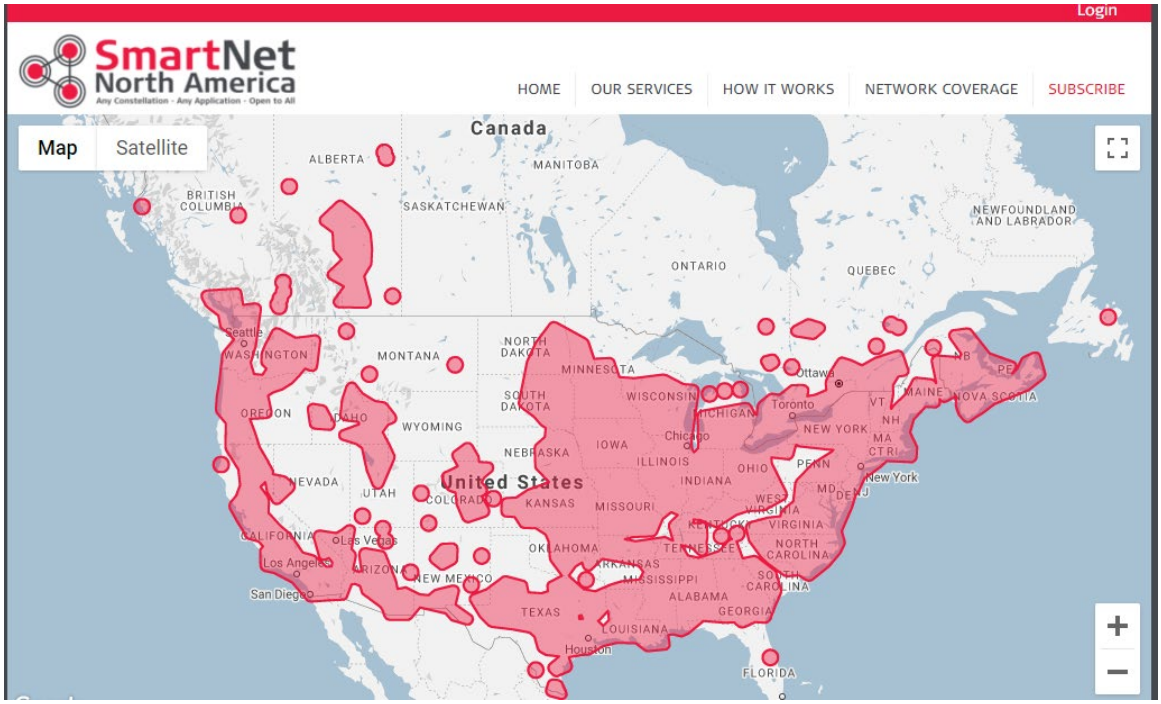
We are partners with both MNDOT and Leica and our reference stations are part of their reference network 24/7. We have been using RTK and RTN since the technology was first offered. We were test users for MNDOT's VRS network beginning in 2003.
We have performed Static and RTK surveys since 1997.

Please let us know if you have any further questions.

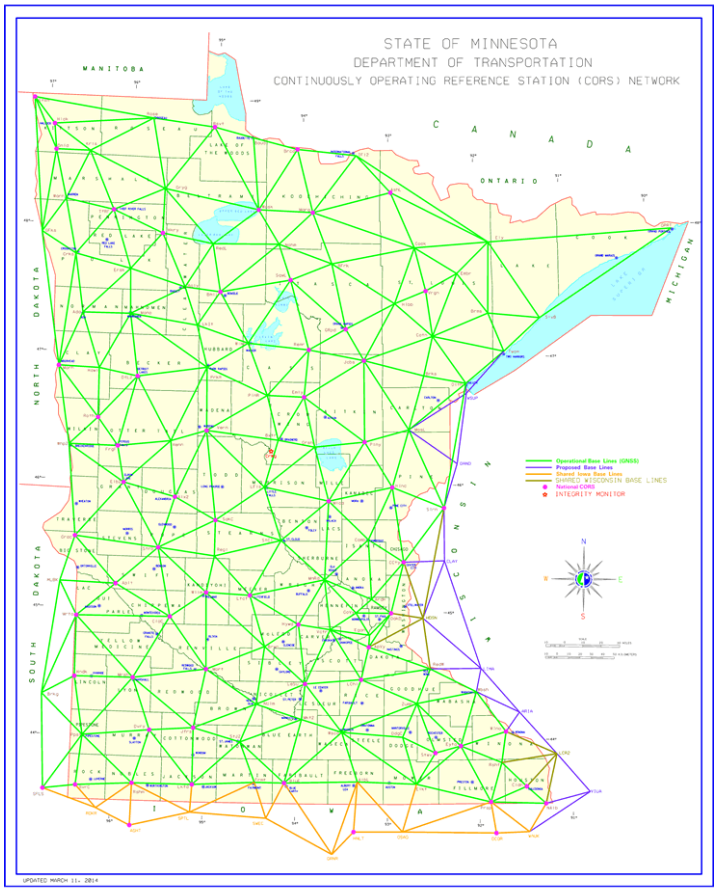
Lisa M. Hanni
Goodhue County Surveyor
Goodhue County, MN

Jeff Ekblad
Deputy County Surveyor
Goodhue County, MN

LEICA SmartNet Coverage:




MNCORS Network:



GNSS SPECIFICATIONS:

# Leica Viva GS16

| | | |
|---|---|---|
| **GNSS TECHNOLOGY** | | |
| Self-learning GNSS | Leica RTKplus<br>SmartLink (worldwide correction service)<br><br>SmartLink fill (worldwide correction service) | Adaptive on-the-fly satellite selection<br>Remote precise point positioning (3 cm 2D)[1]<br>Initial convergence to full accuracy 20 - 40 min, Re-convergence < 1 min<br>Bridging of RTK outages up to 10 min (3 cm 2D)[1] |
| Leica SmartCheck | Continuous check of RTK solution | Reliability 99.99% |
| Signal tracking | | GPS (L1, L2, L2C, L5), Glonass (L1, L2, L3[2]),<br>BeiDou (B1, B2, B3[2]), Galileo (E1, E5a, E5b, Alt-BOC, E6[2]),<br>QZSS (L1, L2, L5, LEX[2]), NavIC L5[3], SBAS (WAAS, EGNOS, MSAS, GAGAN),<br>L-band |
| Number of channels | | 555 (more signals, fast acquisition, high sensitivity) |
| **MEASUREMENT PERFORMANCE & ACCURACY**[1] | | |
| Time for initialisation | | Typically 4 s |
| Real-time kinematic<br>(Compliant to ISO17123-8 standard) | Single baseline<br>Network RTK | Hz 8 mm + 1 ppm / V 15 mm + 1 ppm<br>Hz 8 mm + 0.5 ppm / V 15 mm + 0.5 ppm |
| Post processing | Static (phase) with long observations<br>Static and rapid static (phase) | Hz 3 mm + 0.1 ppm / V 3.5 mm + 0.4 ppm<br>Hz 3 mm + 0.5 ppm / V 5 mm + 0.5 ppm |
| Code differential | DGPS / RTCM | Typically 25 cm |
| **COMMUNICATIONS** | | |
| Communication ports | Lemo<br>Bluetooth® | USB and RS232 serial<br>Bluetooth® v2.00 + EDR, class 2 |
| Communication protocols | RTK data protocols<br>NMEA output<br>Network RTK | Leica, Leica 4G, CMR, CMR+, RTCM 2.2, 2.3, 3.0, 3.1, 3.2 MSM<br>NMEA 0183 V 4.00 and Leica proprietary<br>VRS, FKP, iMAX, MAC (RTCM SC 104) |
| Built-in data links | 3.75G GSM / UMTS / CDMA phone modem<br>Radio modem | Fully integrated, internal antenna<br>Fully integrated, receive and transmit, external antenna<br>403 - 470 MHz, 1 W output power, up to 28800 bps over air |
| External data links | | GSM / GPRS / UMTS / CDMA and UHF / VHF modem |
| **GENERAL** | | |
| Field controller and software | Leica Captivate software | Leica CS20 field controller, Leica CS35 tablet |
| User interface | Buttons and LEDs<br>Web server | On / Off and Function button, 7 status LEDs<br>Full status information and configuration options |
| Data recording | Storage<br>Data type and recording rate | Removable microSD card, 8 GB<br>Leica GNSS raw data and RINEX data at up to 20 Hz |
| Power management | Internal power supply<br>External power supply<br>Operation time[4] | Exchangeable Li-Ion battery (2.6 Ah / 7.4 V)<br>Nominal 12 V DC, range 10.5 - 28 V DC<br>7 h receiving (Rx) data with internal radio, 5 h transmitting (Tx) data with internal radio, 6 h Rx / Tx data with internal phone modem |
| Weight and dimensions | Weight<br>Diameter x Height | 0.93 kg / 3.20 kg standard RTK rover setup on pole<br>190 mm x 90 mm |
| Environmental | Temperature<br>Drop<br>Proof against water, sand and dust<br><br>Vibration<br><br>Humidity<br><br>Functional shock | -40 to 65°C operating, -40 to 80°C storage<br>Withstands topple over from a 2 m survey pole onto hard surfaces<br>IP68 (IEC60529 / MIL STD 810G 506.5 I / MIL STD 810G 510.5 I / MIL STD 810G 512.5 I)<br><br>Withstands strong vibration (ISO9022-36-08 / MIL STD 810G 514.6 Cat.24)<br><br>100% (ISO9022-13-06 / ISO9022-12-04 / MIL STD 810G 507.5 I)<br><br>40 g / 15 to 23 msec (MIL STD 810G 516.6 I) |

| LEICA VIVA GS16 - GNSS SMART ANTENNA | Basic | Performance | Unlimited |
|---|---|---|---|
| **SUPPORTED GNSS SYSTEMS** | | | |
| Multi-frequency | • | ✔ | ✔ |
| GPS / GLONASS / Galileo / BeiDou | ✔ / • / • / • | ✔ / • / • / • | ✔ / ✔ / ✔ / ✔ |
| **RTK PERFORMANCE** | | | |
| DGPS/RTCM, RTK Unlimited, Network RTK | • | ✔ | ✔ |
| SmartLink fill / SmartLink | • / • | • / • | ✔ / • |
| **POSITION UPDATE & DATA RECORDING** | | | |
| 5 Hz / 20 Hz positioning | ✔ / • | ✔ / ✔ | ✔ / ✔ |
| Raw data / RINEX data logging / NMEA out | ✔ / • / • | ✔ / • / • | ✔ / ✔ / ✔ |
| **ADDITIONAL FEATURES** | | | |
| RTK reference station functionality | • | ✔ | ✔ |
| 3.75G or CDMA Phone / UHF Radio (receive & transmit) modem | ✔ / • | ✔ / • | ✔ / • |

✔ Standard • Optional